DOCUMENT RESUME

ED 254 711 CE 040 987

TITLE	Stationary Engineers Apprenticeship. Related Training Modules. 17.1-17.3 Feedwater.
INSTITUTION	Lane Community Coll., Eugene, Oreg.
SPONS AGENCY	Oregon State Dept. of Education, Salem.
PUB DATE	[82]
NOTE	70p.; For related documents, see CE 040 971-990. Many of the modules are duplicated in CE 041 002.
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Apprenticeships; Behavioral Objectives; Energy; Energy Occupations; Equipment Maintenance; Equipment Utilization; Job Skills; Job Training; Learning Modules; Postsecondary Education; *Power Technology; *Trade and Industrial Education; Water; *Water Treatment
IDENTIFIERS	*Feedwater; *Stationary Engineering

ABSTRACT

This learning module, one in a series of 20 related training modules for apprentice stationary engineers, deals with feedwater. Addressed in the individual instructional packages included in the module are the following topics: types of feedwater, equipment for use in working with feedwater, water treatments, and procedures for testing feedwater. Each instructional package in the module contains some or all of the following: a lesson goal, performance indicators, a study guide, a vocabulary list, an introduction, instructional text, an assignment, a job sheet, a self-assessment activity, a post-assessment instrument, answers to the post-assessment instrument, and a list of recommended supplementary references. (MN)

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ED254711

APPRENTICESHIP

STATIONARY ENGINEERS

RELATED TRAINING MODULES

17.1 - 17.3 FEEDWATER

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APPRENTICESHIP

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RELATED TRAINING MODULES

COMPUTERS

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1.2 Digital Logic
1.3 Computer Overview
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2.3 Power Tool Safety
2.4 Fire Safety
2.5 Hygiene Safety
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4.2 Boring and Drilling Tools
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5.12 Series Resistive Circuits
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5.15 Switches and Relays
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STATIONARY ENGINEER
SUPPLEMENTARY REFERENCE DIRECTORY

Note: All reference packets are numbered on the upper right-hand corner of the respective cover page.

Supplementary Packet #	Description	Related Training Module
12.1	Correspondence Course, Lecture 1, Sec. 2, Steam Generators, Types of Boilers I, S.A.I.T., Calgary, Alberta, Canada	12.1 Boilers, Fire Tube Type
12.2	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Types of Boilers II, S.A.I.T., Calgary, Alberta, Canada	12.2 Boilers, Water Tube Type
12.3	Correspondence Course, Lecture 2, Sec. 2, Steam Generators, Boiler Construction & Erection, S.A.I.T., Calgary, Alberta, Canada	12.3 Boilers, Construction
12.4	Correspondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fittings II, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.4	Corresondence Course, Lecture 4, Sec. 2, Steam Generators, Boiler Fitting I, S.A.I.T., Calgary, Alberta, Canada	12.4 Boilers, Fittings
12.5	Correspondence Course, Lecture 10, Sec. 2, Steam Generation, Boiler Operation, Maintenance, Inspection, S.A.I.T., Calgary, Alberta, Canada	12.5 Boilers, Operation
12.7	Correspondence Course, Lecture 3, Sec. 2, Steam Generation, Boiler Details, S.A.I.T., Calgary, Alberta, Canada	12.7 Boilers Heat Recovery Systems
12.8	Refer to reference packet 14.3/12.8	
		PUMPS
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13.7		13.7 Maintenance
13.3	Correspondence Course, Lecture 6, Sec. 3, Steam Generators, Pumps, S.A.I.T., Calgary, Alberta, Canada	13.3 Construction
13.5		13.5 Operation

Supplementary Packet #	Description	Related Training Module
14.3 12.8	Correspondence Course, Lecture 6, Section 3, Steam Generators, Steam Generator Controls, S.A.I.T., Calgary, Alberta, Canada	14.3 Steam, Transport 12.8 Boilers, Instruments & Controls
14.4	Correspondence Course, Lecture 11, Section 2, Steam Generators, Piping II, S.A.I.T., Calgary, Alberta, Canada	14.4 Steam, Purification
15.1	Correspondence Course, Lecture 1, Sec. 4, Prime Movers & Auxiliaries, Steam Turbines, S.A.I.T., Calgary, Alberta, Canada	15.1 Steam Turbines, Types
15.2	Correspondence Course, Lecture 4, Sec. 3, Prime Movers, Steam Turbines I, S.A.I.T., Calgary, Alberta, Canada	15.2 Steam Turbines, Components
15.3	Correspondence Course, Lecture 2, Sec. 4, Prime Movers & Auxiliaries, Steam Turbine Auxiliaries, S.A.I.T., Calgary, Alberta, Canada	15.3 Steam Turbines, Auxiliaries
15.4	Correspondence Course, Lecture 6, Sec. 3, Prime Movers, Steam Turbine Operation & Maintenance, S.A.I.T., Calgary, Alberta, Canada	15.4 Steam Turbines, Operation & Maintenance
15.5	Correspondence Course, Lecture 8, Sec. 3, Prime Movers, Gas Turbines, S.A.I.T., Calgary, Alberta, Canada	15.5 Gas Turbines
16.2	Boilers Fired with Wood and Bark Residues, D.D. Junge, F.R.L., O.S.U. 1975	16.2 Combustion Types of Fuel
16.2	Correspondence Course, Lecture 5, Sec. 2, Steam Generators, Fuel Combustion, S.A.I.T., Calgary, Alberta, Canada	16.2 Combustion Types of Fuel
16.3	Correspondence Course, Lecture 5, Sec. 2, Plant Services, Fuel & Combustion, S.A.I.T., Calgary, Alberta, Canada	16.3 Combustion, Air & Fuel Gases
17.1	Correspondence Course, Lecture 12, Sec. 3, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.1 Feed Water, Types & Operation
17.2	Correspondence Course, Lecture 12, Sec. 2, Steam Generation, Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.2 Feed Water, Water Treatments

Supplementary Packet #	Description	Related Training Module
17.3	Correspondence Course, Lecture 7, Sec. 2, Steam Generators, Boiler Feed Water Treatment, S.A.I.T., Calgary, Alberta, Canada	17.3 Feed Water, Testing
18.1	Correspondence Course, Lecture 2, Sec. 5, Electricity, Direct Current Machines, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction
18.1 18.2	Correspondence Course, Lecture 4, Sec. 5, Electricity, Alternating Current Generators, S.A.I.T., Calgary, Alberta, Canada	18.1 Generators, Types & Construction 18.2 Generators, Operation
19.1	Corrspondence Course, Lecture 5, Sec. 4, Prime Movers & Auxiliaries, Air Compressor I, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types
19.1 19.2	Correspondence Course, Lecture 6, Sec. 4, Prime Movers & Auxiliaries, Air Compressors II, S.A.I.T., Calgary, Alberta, Canada	19.1 Air Compressors, Types 19.2 Air Compressors, Operation & Maintenance
20.1	Basic Electronics, Power Transformers, EL-BE-51	20.1 Transformers
21.1	Correspondence Course, Lecture 7, Sec. 5, Electricity, Switchgear & Circuit, Protective Equipment, S.A.I.T., Calgary, Alberta, Canada	21.1 Circuit Protection
22.1	Correspondence Course, Lecture 10, Sec. 3, Prime Movers, Power Plant Erection & Installation, S.A.I.T., Calgary, Alberta, Canada	22.1 Installation Foundations

RECOMMENDATIONS FOR USING TRAINING MODULES

The following pages list modules and their corresponding numbers for this particular apprenticeship trade. As related training classroom hours vary for different reasons throughout the state, we recommend that the individual apprenticeship committees divide the total packets to fit their individual class schedules.

There are over 130 modules available. Apprentices can complete the whole set by the end of their indentured apprenticeships. Some apprentices may already have knowledge and skills that are covered in particular modules. In those cases, perhaps credit could be granted for those subjects, allowing apprentcies to advance to the remaining modules.

We suggest the the apprenticeship instructors assign the modules in numerical order to make this learning tool most effective.

SUPPLEMENTARY INFORMATION

ON CASSETTE TAPES

Tape 1: Fire Tube Boilers - Water Tube Boilers and Boiler Manholes and Safety Precautions

Tape 2: Boiler Fittings, Valves, Injectors, Pumps and Steam Traps

Tape 3: Combustion, Boiler Care and Heat Transfer and Feed Water Types

Tape 4: Boiler Safety and Steam Turbines

NOTE: The above cassette tapes are intended as additional reference material for the respective modules, as indicated, and not designated as a required assignment.

17.1

FEEDWATER -- TYPES AND EQUIPMENT

Goal:

The apprentice will be able to describe feedwater types and equipment.

Performance Indicators:

1. Describe types of water.
2. Describe equipment for clarification.
3. Describe equipment for softening.
4. Describe equipment for thermal treatment.

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary

* Anion exchanger
* Cation exchanger
* Clarification
* closed feedwater heater
* Coagulants
* Deaerator
* Demineralization
* Dissolved gases
* Embrittlement
* Estuarine water
* Filters
* Flash evaporator
* Hard water
* Open feedwater heater
* Rain water
* Scheens and strainers
* Settling basin
* Shell and tube evaporator
* Soft water
* Softening
* Suspended matter

Introduction

Raw water is found in many forms of purity. Rain water hits the earth in a reasonably pure form except for the oxygen and carbon dioxide it has picked up on its way down. In areas with acid rain, it might collect far more than oxygen and carbon dioxide.

Once the water has percolated through earth and rocks, it becomes either hard water or soft water. This depends on the chemicals picked up as it percolated through the rocks.

One can safely assume that all types of water needs treatment before it is placed in a boiler. Such treatments require equipment for clarification, softening and heating. This package describes some of the equipment needed for feedwater treatment.

Information

TYPES OF WATER

Feedwater comes from several natural sources that have different levels of water quality. The basic categories of natural water are:

1. Rain water
2. Hard water
3. Soft water
4. Estuarine water

Rain Water

Rain water has a high level of carbon dioxide and oxygen. This causes it to be corrosive. It is low in mineral content which reduces the problem from scale. Still it must be treated to remove the dissolved gases which cause corrosion.

Hard Water

Hard water is merely rain water that has traveled through rocks and earth. It picks up calcium and magnesium in the process of moving through the earth. The calcium and magnesium is in the form of carbonates, chlorides and sulphates. These compounds become a problem in feedwater in the form of scale. Hard water must be treated before use as feedwater.

Soft Water

Soft water is rain water that moved through insoluble rocks. The water failed to pick up calcium and magnesium. Soft water may contain suspended matter such as leaves, silt and clay particles that were picked up on its trip through the rocks. Soft water must be treated in settling tanks to remove the suspended matter.

Estuarine Water

Estuarine water comes from estuaries of the sea. It is diluted sea water. The closer it is located to the sea, the heavier the chemical concentration will be. Estuarine water requires careful treatment to be made suitable for boiler feedwater.

Information

EQUIPMENT FOR TREATING WATER

Equipment for Clarification

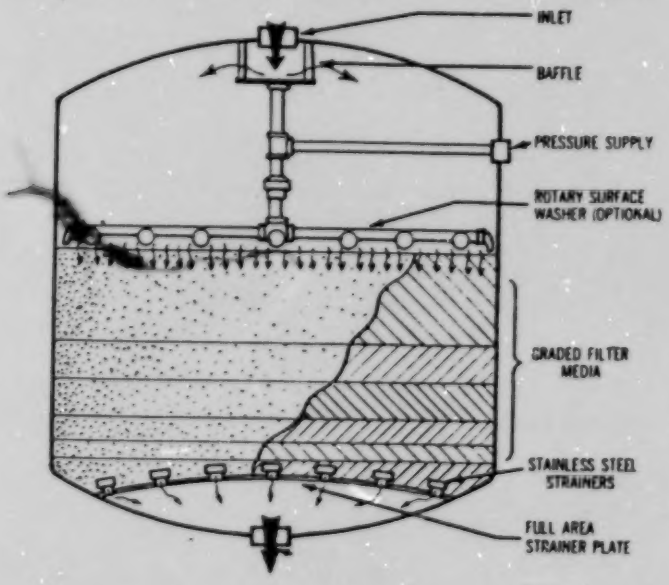
Suspended matter must be removed from feedwater by a process called clarification. This means that the process makes the water clear by removing suspended matter. The equipment uses mechanical treatments to remove particles from the water. The common pieces of equipment for clarification are:

1. Screens and strainers for removing large particles of suspended matter.

2. Settling basins which allows suspended particles to settle to the bottom and be drawn off.

3. Coagulants are sometimes needed to increase the particle size of suspended solids. The particles will then settle to the bottom to be drawn off. This is a mechanical (settling) process even though a chemical coagulant was used to promote settling of the particles.

4. Filters consist of a bed of porous material through which water can pass by either gravity flow or under pressure. The porous material is often sand or anthracite. A pressure filter is shown below.



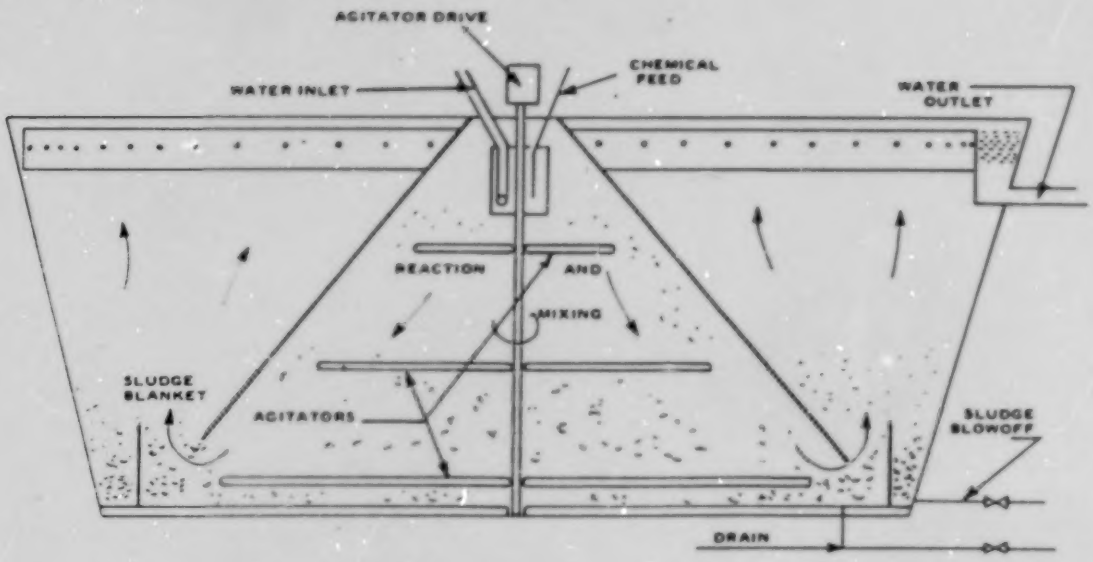
Information

Equipment for Softening

Removal of calcium and magnesium salts from water is often accomplished through softening processess. The common softening processes are:

1. Cold lime-soda
2. Hot line-soda
3. Sodium zeolite
4. Hydrogen zeolite
5. Demineralizion

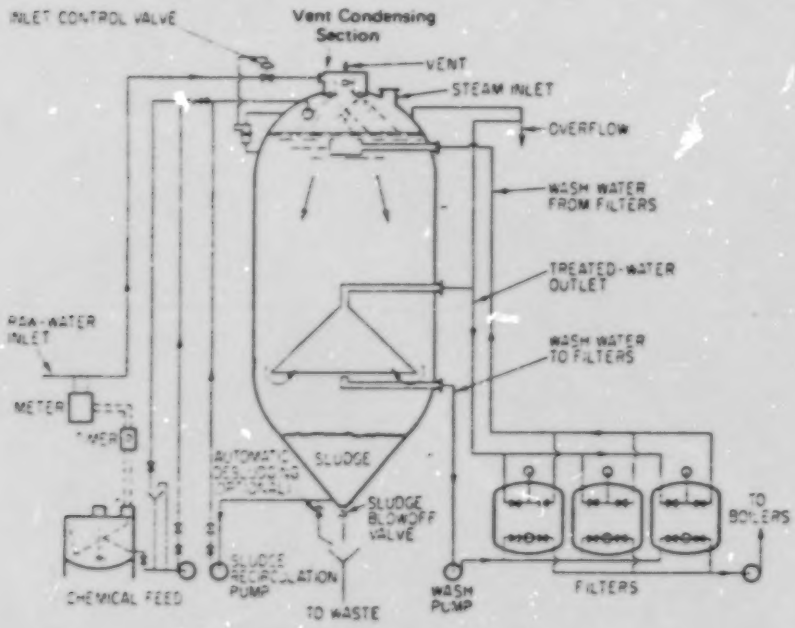
The equipment for cold lime-soda softening requires an agitator to mix the chemicals and a coagulant. The softener combines with scale to form a sludge which can be discharged. The coagulant aids in sludge formation.



Cold Lime-Soda Softener

Information

Hot lime-soda requires that the water be heated above 100 C. This causes a quick chemical reaction between the softener and solids in the water. A hot lime-soda softener is pictured below.



Hot Lime-Soda Softener

The sodium zeolite softener exchanges ions with scale forming solids. The scale forming salts are replaced with sodium cations that do not form scale. Some common zeolites are synthetic gel, sulfonated coal and styrene resin. After the zeolite has collected a load of calcium and magnesium cations from the solids, the zeolite container is filled with brine. The brine removes the load of calcium and magnesium ions from the zeolite. The brine can then be flushed out and the zeolite reused. A zeolite softener is shown in detail on the next page.

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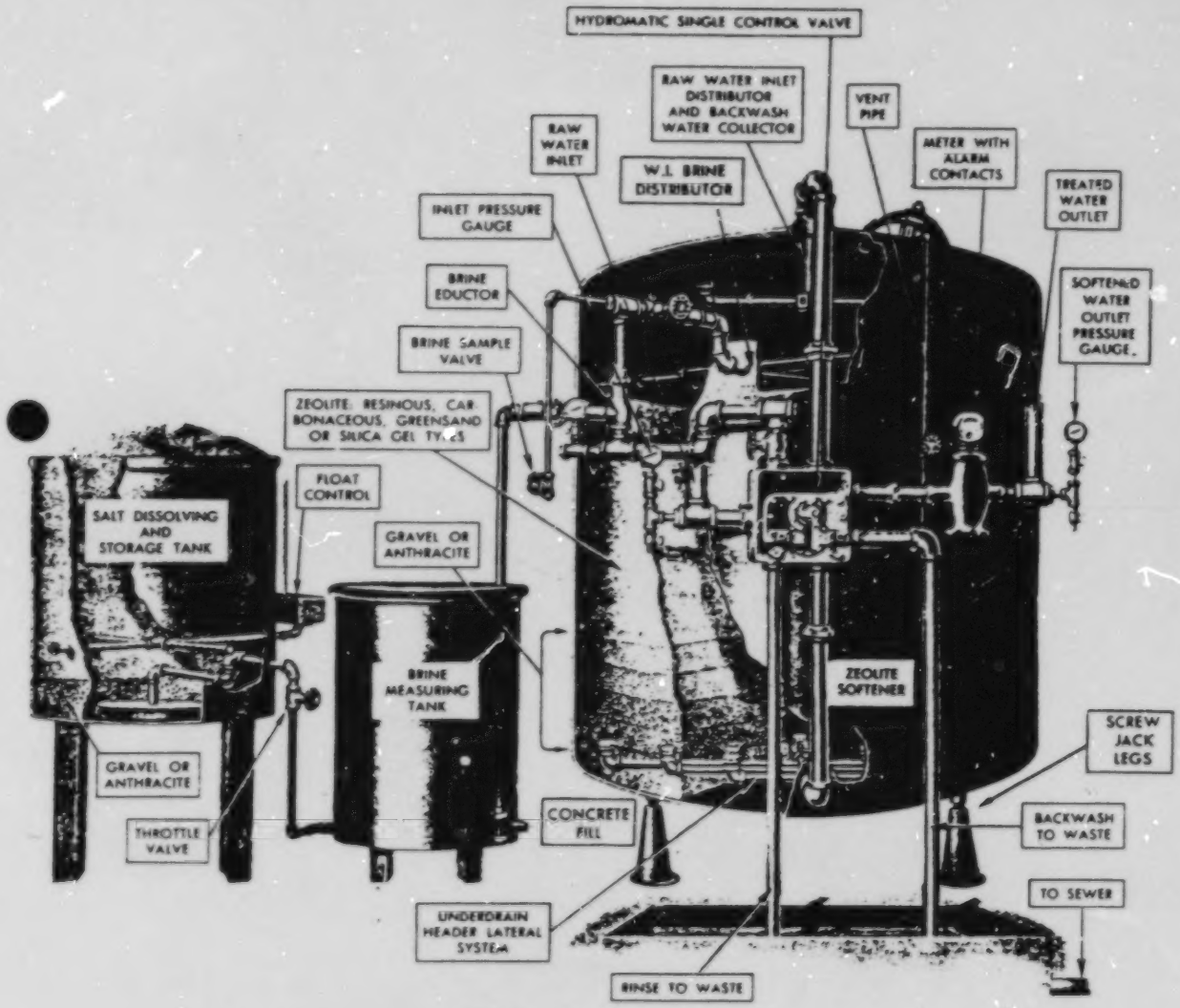
Information



Zeolite Softener Details

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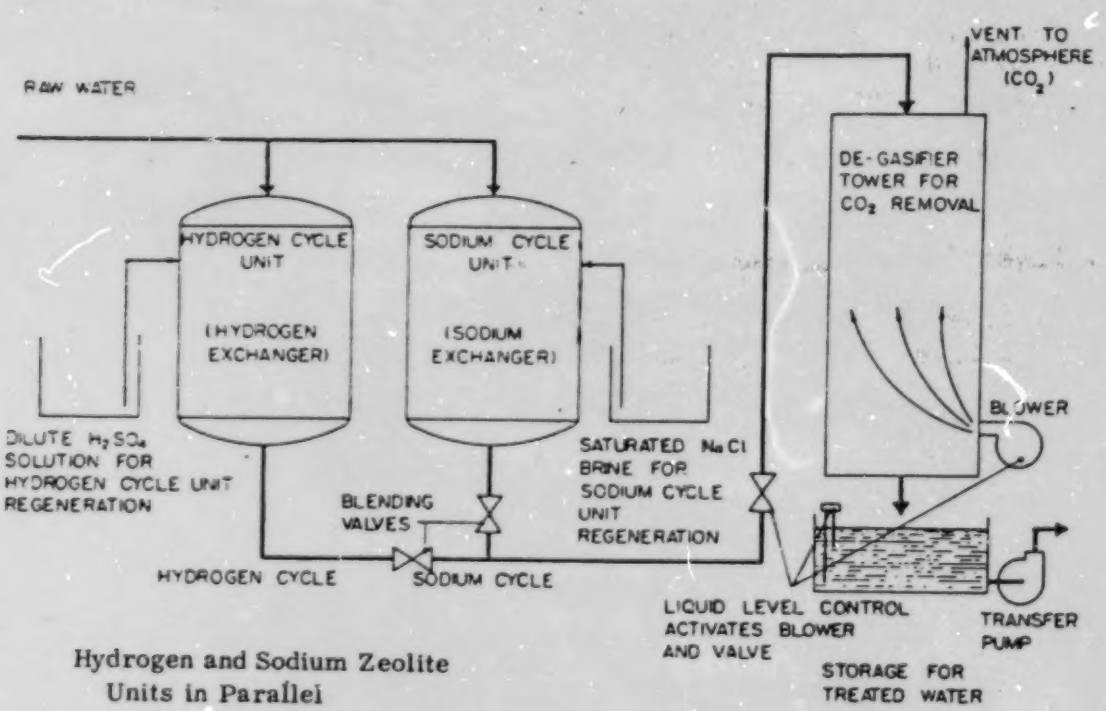
Information

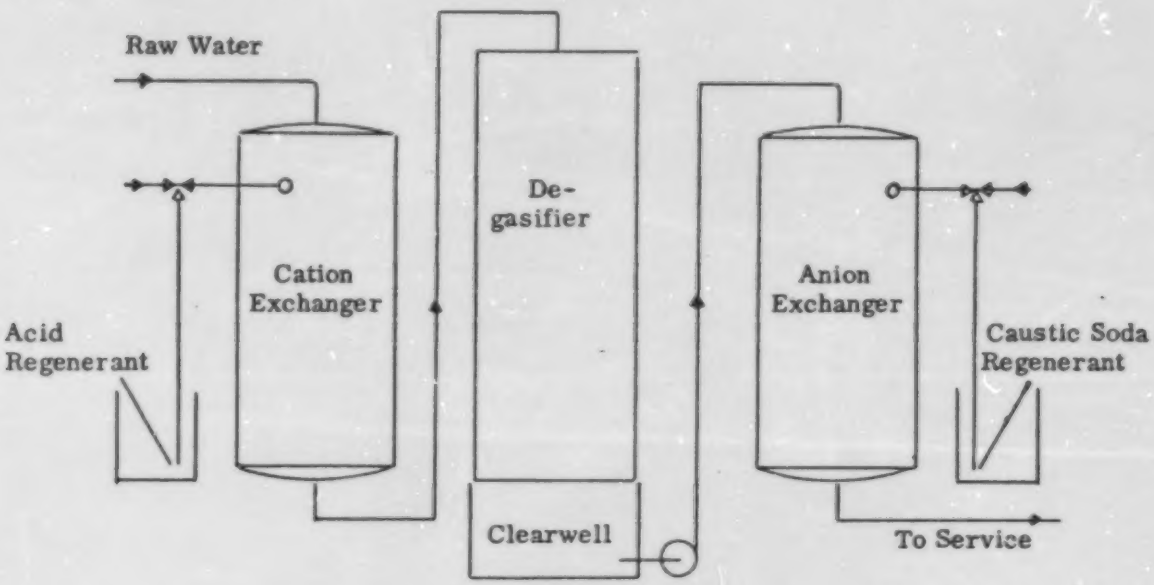
Hydrogen zeolites are often used instead of sodium zeolites. A problem of caustic embrittlement can result from the use of sodium zeolites. Sodium hydroxide was one of the by-products of sodium zeolite softening. This by-product can cause embrittlement. Hydrogen zeolites will remove the scale forming salts without forming the by-products that cause embrittlement. A hydrogen zeolite is made from lignite, sulphonated coal or synthetic resin. A method of carbon dioxide removal must be used with this type of softener. The hydrogen zeolite is often used in parallel with the sodium zeolite unit and a degasifier.



Hydrogen and Sodium Zeolite Units in Parallel

Demineralization uses the principles of anion and cation exchange to remove all salts from the water. A hydrogen zeolite cation exchanger removes sodium, magnesium and calcium. The anion exchanger removes sulphide, chloride and silicia anions. A degasifier removes the carbon dioxide from the water.

Information



Demineralizing Arrangement

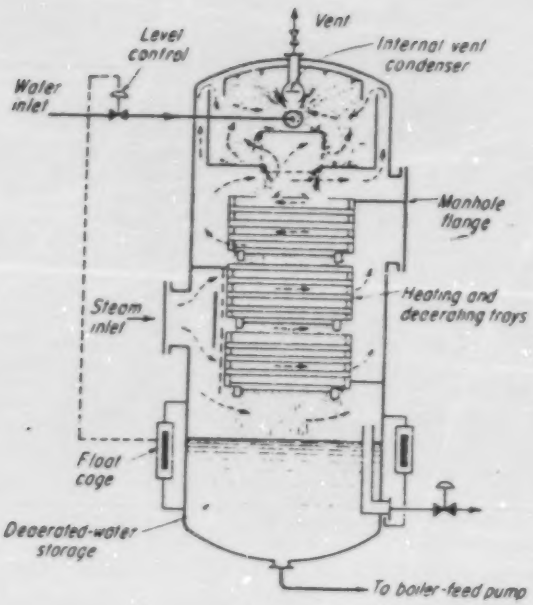
Equipment for Thermal Treatments

Heat can be used to treat feedwater. The most economical use of heat is to remove dissolved gases from the feedwater. Thermal treatment involves the use of:

1. Deaerators
2. Feedwater heaters
3. Evaporators

Dearators are of a spray type or a tray type. Basically, the deaerator heats the water to boiling and removes the gases through a scrubbing process. A combination spray and tray type deaerator is shown.

Information



Combination Spray
and
Tray Deaerator

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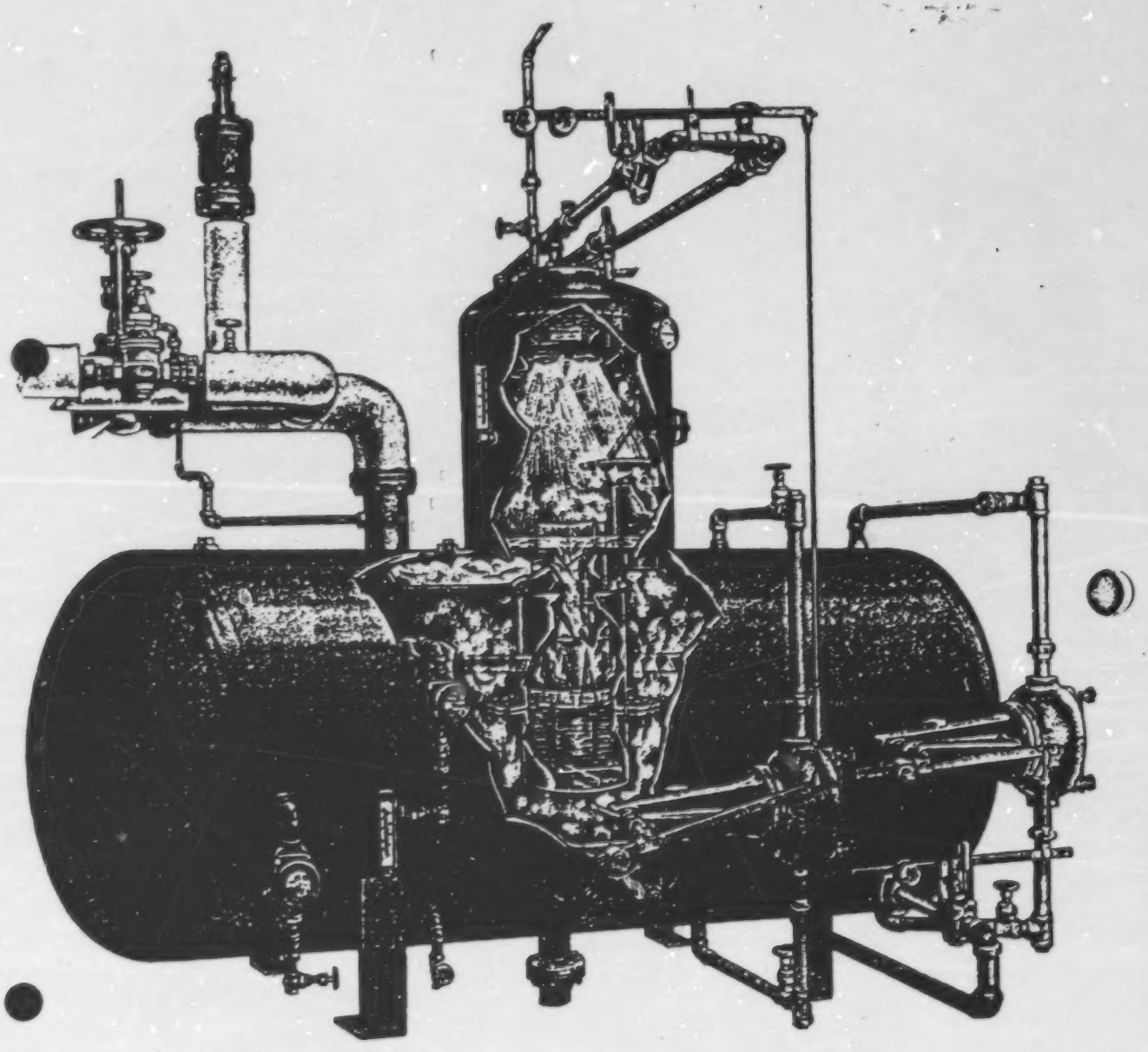
Information

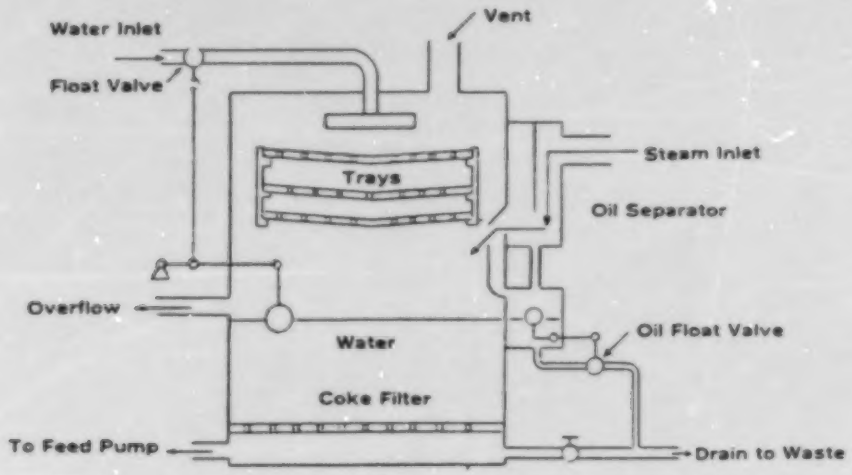
A spray deaerator is pictured below.



13

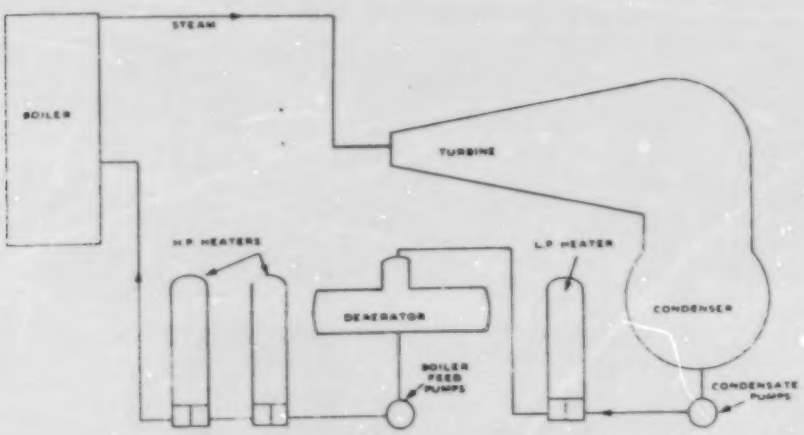
Information

Feedwater heaters are used to soften, deaerate and filter water. They also serve the purpose of heating the feedwater. Bicarbonates are broken into carbon dioxide which has the effect of softening the water. Feedwater heaters may be open or closed types. Open feedwater heaters operate at atmospheric pressure and below boiling point. A closed heater allows water to be heated to high temperatures. The open heater is shown below.



Open Feedwater Heater

A closed feedwater is built into the system as shown.



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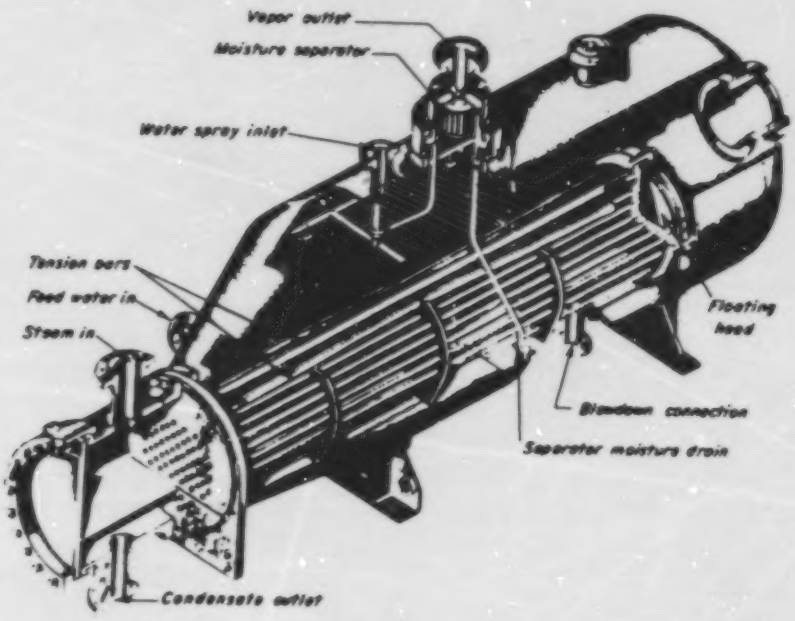
Information

Evaporators are used to distill water for a system. The evaporator removes all solids. A deaerator should be used in tandem with an evaporator to remove the soluble gases. Evaporators are made in three types:

1. Shell and tube
2. Flash
3. Demineralizers

The figure below shows a shell and tube type evaporator.



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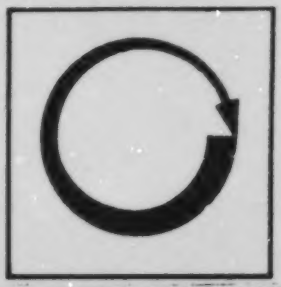
Assignment



* Read pages 7 - 33 in supplementary reference.
* Complete the job sheet.
* Complete self-assessment and check answers.
* Complete post-assessment and ask the instructor to check your answers.

Job Sheet

ANALYZE WATER TREATMENT EQUIPMENT AT YOUR JOB SITE OR OTHER VISITATION SITE

* Obtain manufacturer's specifications and instructions for water treatment equipment at a specific site.

* What type of equipment is used for:

  - Clarification?
  - Softening?
  - Thermal treatment?

* What kind of water is used for feedwater?

  - Rain water
  - Hard water
  - Soft water
  - Estuarine water

* Is the equipment appropriate to the needs?

  - What are the water problems?
  - How well are problems controlled?

* Visually inspect water treatment equipment for better understanding of its components.

Self Assessment

Match the following terms with appropriate phrases.

____	1. Settling basin	A. Used to increase the size of particles of suspended matter.
____	2. Cold lime-soda	B. Softener that exchanges ions with scale forming solids.
____	3. Hard water	C. Is actually diluted seawater.
____	4. Sodium zeolite	D. Process for removal of suspended matter from feedwater.
____	5. Soft water	E. Contains scale forming carbonates chlorides and sulphates.
____	6. Rain water	F. Porous bed of anthracite or sand.
____	7. Coagulant	G. Must be treated to remove oxygen and carbon dioxide.
____	8. Clarification	H. May contain suspended matter but is low in solids.
____	9. Filter	I. Allows suspended particles to be drawn off at the bottom.
____	10. Estuarine water	J. Softener that combines with scale to form a sludge.

Self Assessment Answers

I 1.

J 2.

E 3.

B 4.

H 5.

G 6.

A 7.

D 8.

F 9.

C 10.

Post Assessment

Match the following terms and descriptive phrases.

_____ 1.	Hot lime-soda softener	A. Removes carbon dioxide from water.
_____ 2.	Sodium zeolites	B. A common sodium zeolite.
_____ 3.	Hydrogen zeolite	C. Very quick reaction between softener and solids.
_____ 4.	Degasifier	D. A common hydrogen zeolite.
_____ 5.	Demineralization	E. Can cause embrittlement.
_____ 6.	Deaerator	F. Used to avoid embrittlement problems.
_____ 7.	Styrene resin	G. May be shell or tube or flash types.
_____ 8.	Lignite	H. May be of spray or tray types.
_____ 9.	Evaporator	I. May be of open or closed types.
_____ 10.	Feedwater heater	J. Removes all salts from water and uses both anion and cation exchange principles.

Instructor Post Assessment Answers

C 1.

E 2.

F 3.

A 4.

J 5.

H 6.

B 7.

D 8.

G 9.

I 10.

Supplementary References

* Correspondence Course. Lecture 12, Section 3, Third Class. Steam Generation. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.

17.2

FEEDWATER -- WATER TREATMENTS

Goal:

The apprentice will be able to describe the basic feedwater treatments.

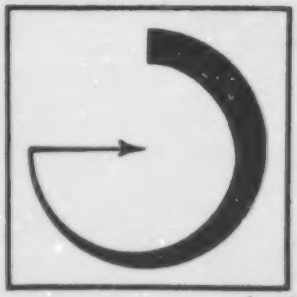
Performance Indicators:

1. Describe external treatments.
2. Describe internal treatments.
3. Describe sampling of boiler water and steam for testing.

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Anion exchanger
* Caustic embrittlement
* Carryover prevention
* Chemical coagulation
* Continuous hot process softener
* Continucus sedimentation cold process softener
* Continuous sludge contact cold process softener
* Deaerators
* Deionization process
* Demineralized water
* Dissolved gases
* Dissolved solids
* Evaporation
* External treatment
* Filtration
* Foaming
* Hot lime--hot ion exchange softener
* Hot lime--phosphate softener
* Hydrazine
* Hydrogen ion exchanger
* Intermittent cold process softener
* Internal treatment
* pH control
* Priming
* Return line corrosion
* Reverse osmosis
* Sample cooler
* Sample testing
* Scale prevention
* Settling tanks
* Sodium hydroxide
* Sodium ion exchanger
* Sodium phosphate
* Spray type deaerator
* Steam sample
* Suspended matter
* Tray type deaerator
* Water sample
* Water softener
* Zeolite

Introduction

A steam plant is troubled with scale deposits and corrosion. Scale deposits reduce the ability of the unit to transfer heat. The level of scale formation is determined by the content and purity of the water used to make steam. High purity water used to make steam. High purity water becomes a major concern for the boiler operator.

This water is heated to form steam. As the water is transformed to steam, more water is fed into the boiler. The term feedwater is used to describe water that is fed into the boiler to become steam.

To avoid damage from feedwater, the water should be tested and the water treated according to the findings of the tests. Follow-up tests should be conducted to make sure that the treatment corrected the problem of water quality.

Information

Water Treatment

The purpose of feedwater treatment is to:

1. Remove salts that form scale.
2. Remove acid-forming materials.
3. Reduce dissolved oxygen content.
4. Regulate total dissolved solids content.

Water impurities that cause problems in feedwater are:

1. Suspended matter is material that does not dissolve in water and can be removed by filtering. Examples are organic material, clay, mud.

2. Dissolved solids such as calcium, magnesium and silica make compounds that form scale deposits. This problem requires treatment of the feedwater.

3. Dissolved gases such as oxygen and carbon dioxide corrode the boiler and piping. Mechanical aeration and chemical treatments are used to remove the dissolved gases from the feedwater.

The methods of treatment may be classified as:

1. External treatment of the water before it enters the boiler, i.e. evaporation, filters, deaerators.

2. Internal treatment by chemical means after it enters the boiler.

External Methods of Treatment

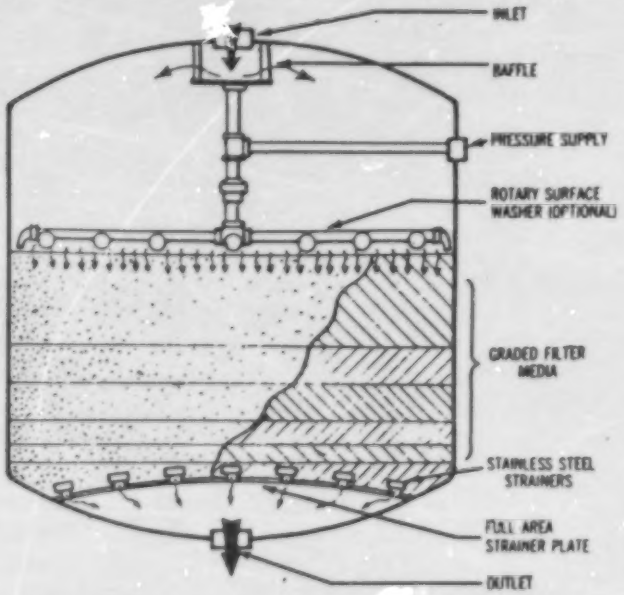
Several external methods of water treatment are used to purify the feedwater.

1. Settling tanks can be used to settle out suspended matter. Water is allowed to stand in the settling tank until suspended matter settles to the bottom and is drawn off. If the suspended matter is a fine particle such as clay, chemical coagulation can be used to increase the particle size and make it settle out. Aluminum compounds are common coagulants. Coagulation also removes some solids other than suspended matter.

2. Filtration involves passing raw water through filters of sand and gravel or other media. Filters trap most suspended materials.

Information

Pressure filters will remove finer particles than a gravity filter unit. The filter media is graded in density and pressure is applied to push the water through the filter. A drawing of a pressure filter is shown.



3. Water softeners are used to remove scale forming dissolved solids from the feedwater. Lime (calcium hydroxide) and soda (sodium carbonate) precipitate the solids. A coagulant is then used to settle out the dissolved solids. Lime-soda softeners may be used as the intermittent cold process softeners for small plants; as continuous sedimentation cold process softeners that are continuously mixing lime and soda with water and the sedimentation process is on-going; continuous sludge contact cold process softener that mixes raw water with sludge and chemicals; and the continuous hot process. The continuous hot process softener is the most widely used. Chemicals and water are mixed and immediately heated to 100 C by steam. The solids precipitate and are removed by blow down. The hot lime-hot phosphate softener uses hot phosphate along with the hot lime softener. Almost all dissolved solids can be removed through this treatment. The hot lime softener can be combined with an ion exchanger to remove hardness and carbon dioxide from the water. A hot lime-hot ion exchange softener is shown on the next page.

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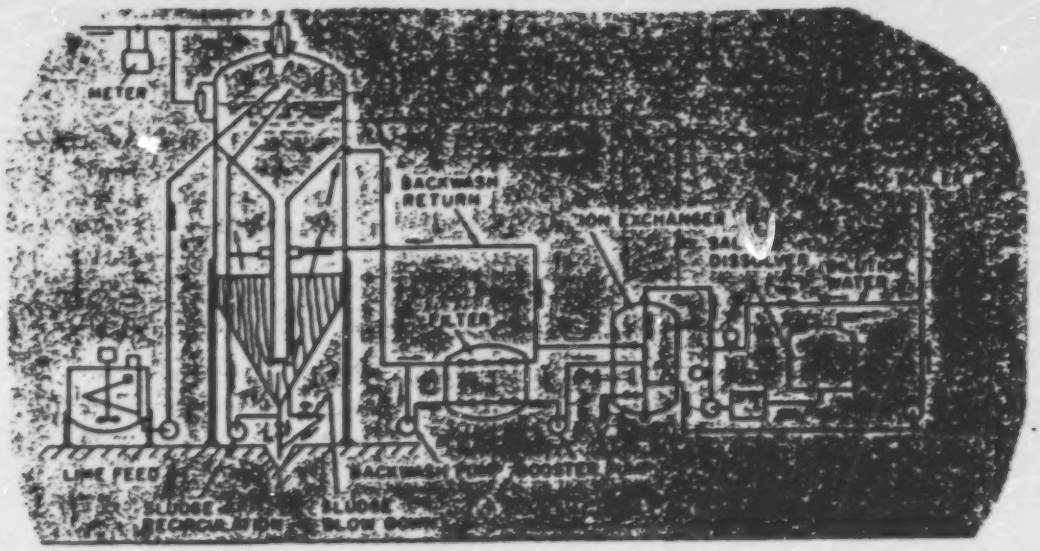
Information



Hot Lime - Hot Ion Exchange

In the sodium ion exchanger, a sodium zeolite softener converts scale forming compounds to non-scale forming compounds. The zeolite changes calcium and magnesium to sodium compounds through ion exchange.

The hydrogen ion exchanger uses a hydrogen zeolite and converts calcium and magnesium into acids and then the acids are neutralized with sodium hydroxide. This softener avoids having carbon dioxide formed from the sodium bicarbonate that is the case with other softeners. The carbon dioxide causes erosion problems in boiler parts. Demineralized water uses a deionization process. First a hydrogen zeolite is used as a cation exchange to remove calcium and magnesium. Then an anion exchanger is used to remove sulphate, chloride and silica anions. A degasifier is used to remove carbon dioxide. This makes mineralized water almost as pure as distilled water.

Reverse osmosis is another system for cleaning up water. In osmosis, a dilute solution will pass through a membrane to a concentrated solution. However, if pressure is applied on the concentrated side, the fluid will pass to the dilute side in a reverse osmosis. If raw water is forced through a membrane, the impurities will be left behind. A reverse osmosis type softener is shown.

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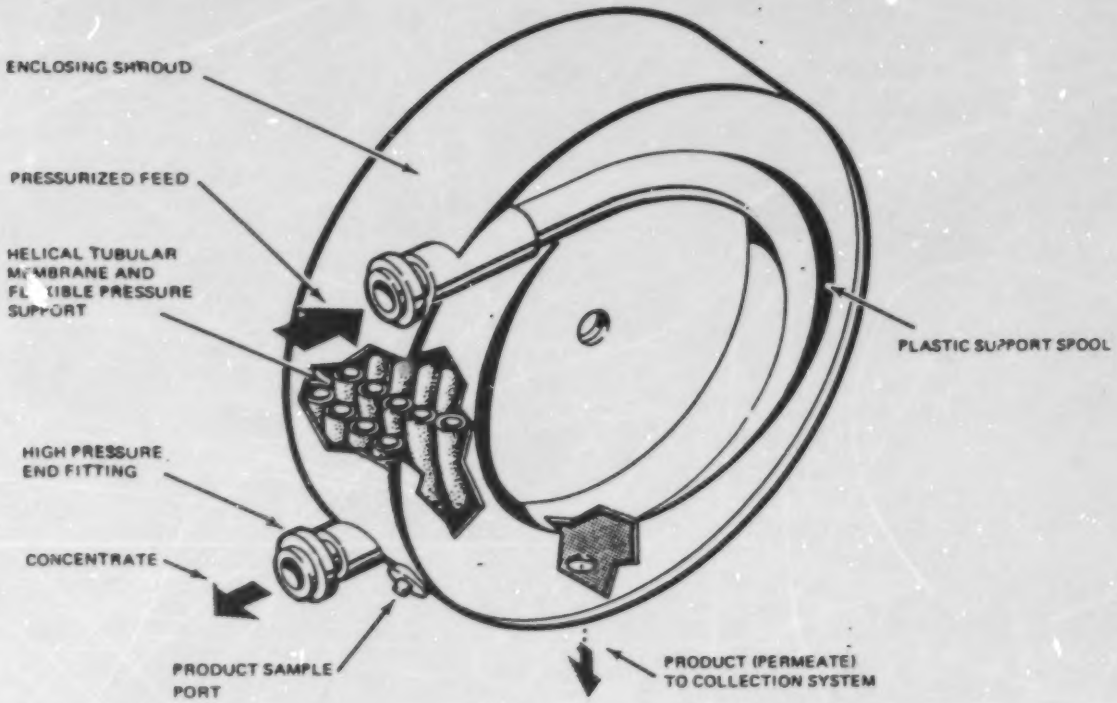
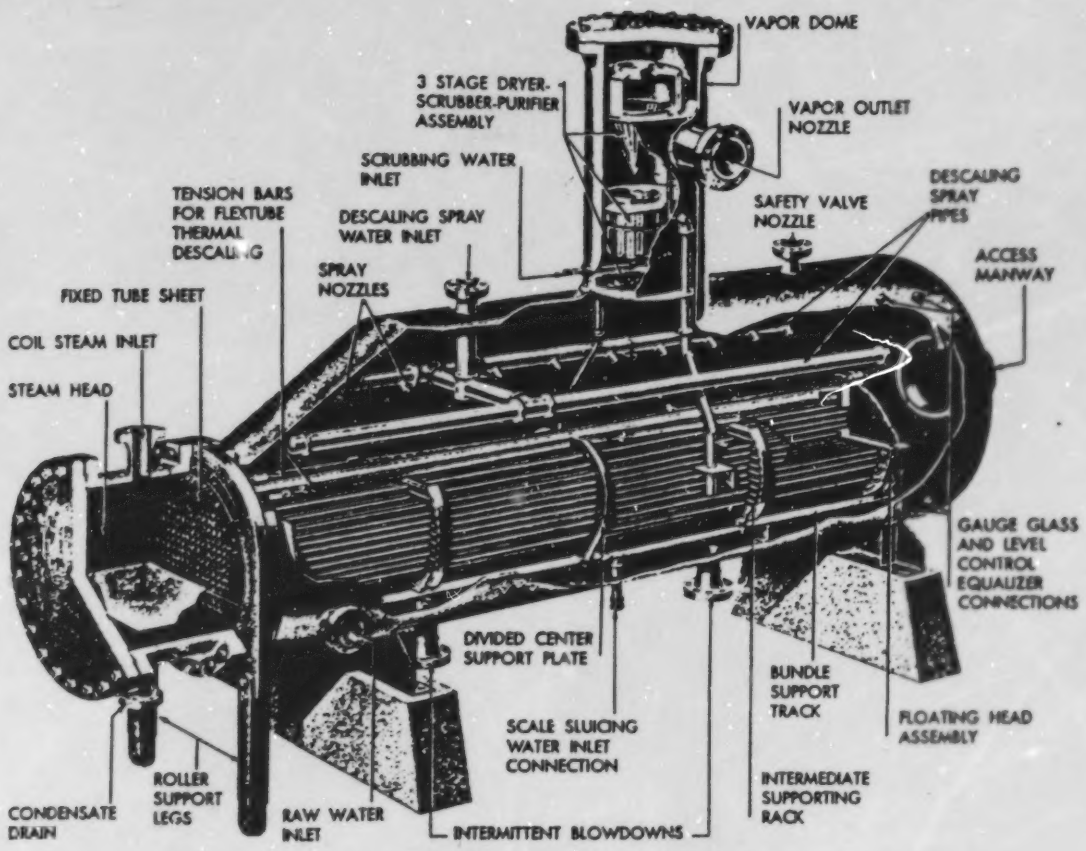
Information



4. Evaporation involves boiling water. The steam from boiling water is condensed and used as feedwater. Deaerators are used with evaporators so that both dissolved gases and minerals are removed from the feedwater. Water is usually softened before evaporation to avoid scale formations in the evaporator. A typical evaporator is shown on the following page.

Information



5. Deaeration is used to remove dissolved gases from water. Oxygen and carbon dioxide cause corrosion in boilers. It is wise to remove as much of the dissolved gases as possible through deaeration. Mechanical deaeration involves heating the water to the boiling point and pushing the gases into the atmosphere. During this process the water is scrubbed with steam to remove the gases from the water. Deaerators consist of four sections. They are either of a spray type or tray type. In the spray type water is sprayed into the first section where it is heated; moved through the scrubbing section; moved into storage section as deaerated water; and the gases move to the last section and then outside. The tray type deaerator is very much like the spray type except that the water trickles down over trays instead of being broken up by spray nozzles.

Information

Internal Methods of Treatment

Internal treatment is conducted after the water has entered the boiler. It may be used as the only treatment in some low pressure boilers or in addition to external treatments. Some of those internal treatments are:

1. pH Control -- prevents acids in boiler water from corroding the metal. The pH must be kept high (10.5) by adding a base solution. Sodium hydroxide has been used in years past but is now found to cause a problem called caustic embrittlement. To avoid this problem, operaters should use sodium phosphates for raising the pH level of boiler water.

2. Scale prevention treatments involve precipitating calcium and magnesium salts and removing them as sludge during blow-off. The sodium phosphates are the most suitable chemical for precipitation of salts that later become scale.

3. Oxygen scavenging. The feedwater brings undissolved oxygen into the boiler. This oxygen will cause corrosion of the boiler, feedwater lines, heaters and economizer. Mechanical deaeration should be practiced on all feedwater. In addition, this should be followed by oxygen scavenging or chemical deaeration to remove the remaining oxygen. Sodium sulphite is the chemical to be used in scavenging. With some high pressure boilers hydrazine, a strong alkali, is used for scavenging oxygen.

4. Carryover prevention involves steps to assure that boiler water solids do not leave in the steam. A previous package discussed priming which involves carryover of water in the steam. Foaming is a condition where bubbles form in the boiler. These bubbles cause water to be carried over in the steam. There are many causes for water carryover including chemical and mechanical reasons. Blow-down reduces the amounts of suspended solids and prevents carryover. Such things as oil in the boiler can cause foaming and carryover. There is no internal treatment for oil in the boiler. Many new anti-foam agents are available to help control carryover by foaming.

5. Return line corrosion is caused by carbon dioxide and oxygen in the condensate solution. Mechanical and chemical aeration can prevent problems with oxygen. Carbon dioxide can be controlled by the use of ammonia, neutralizing amines and filming amines. Ammonia is corrosive to copper and zinc bearing metals.

Information

Sampling Boiler Water and Steam

The operator must be able to collect samples for testing. That is the only way to determine the quality and purity of boiler water and steam. The sample must be representative of the total water and steam capacity.

1. Water samples should be collected from an internal pipe or from the continuous blow down pipe. The samples should be cooled to room temperature in a sample cooler.

2. Steam samples are taken from the drum by sampling lines. It is condensed and cooled in a sample cooler.

3. Sample testing must be carefully done to avoid contamination of samples. The test instructions must be followed closely if good results are expected.

Assignment

* Read pages 1 - 33 in the supplementary reference.
* Complete job sheet.
* Complete self-assessment and check answers.
* Complete post-assessment and ask the instructor to check your answers.

Job Sheet

ASSIST OPERATOR IN COLLECTING WATER AND STEAM SAMPLES

* Ask a boiler operator if you can observe the techniques for collecting and preparing samples of water and steam for testing.
* Assist operator in collecting samples.
* Record the steps in collection procedure.
* Record steps in sample preparation such as cooling.

Self Assessment

Match the following terms and phrases.

____	1. Dissolved gases	A.	Removes scale forming dissolved solids from water.
____	2. Dissolved solids	B.	Requires water to pass through a membrane under pressure.
____	3. Suspended matter	C.	Increases particle size so that it will settle out.
____	4. Chemical coagulation	D.	Make compounds that cause scale.
____	5. Water softeners	E.	Involves boiling water into steam and condensing it.
____	6. Demineralized water	F.	Cause corrosion in boiler and piping.
____	7. Zeolite	G.	Does not dissolve in water.
____	8. Evaporation	H.	Used to remove dissolved gases form feedwater.
____	9. Deaeration	I.	Requires cation exchanger, anion exchanger and degasifier to manufacture it.
____	10. Reverse osmosis	J.	Changes calcium and magnesium compounds to sodium compounds.

Self Assessment Answers

F 1.

D 2.

G 3.

C 4.

A 5.

I 6.

J 7.

E 8.

H 9.

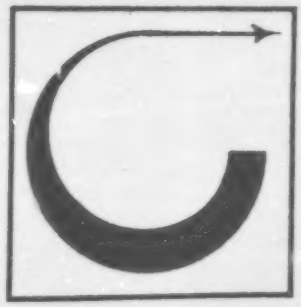
B 10.

Post Assessment

Match the following terms and phrases.

____ 1.	Spray type	A. Removal of oxygen by chemical deaeration.
____ 2.	Sodium hydroxide	B. Removes scale forming elements such as calcium, magnesium and silica.
____ 3.	Sodium phosphate	C. Used to remove suspended matter from water.
____ 4.	Oxygen scavenging	D. Avoids caustic embrittlement.
____ 5.	Foaming	E. Type of deaerator.
____ 6.	Sodium sulphite	F. Chemical used in oxygen scavenging.
____ 7.	Ammonia	G. Causes caustic embrittlement.
____ 8.	Water softener	H. Caused by carbon dioxide and oxygen in the condensate solution.
____ 9.	Settling tank	I. A type of water carryover into steam.
____ 10.	Return line corrosion	J. Corrosive to copper and zinc bearing metal.

Instructor Post Assessment Answers



E 1.

G 2.

D 3.

A 4.

I 5.

F 6.

J 7.

B 8.

C 9.

H 10.

Supplementary References

* Correspondence Course. Lecture 12, Section 2, First Class. Steam Generation. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.

INSTRUCTIONAL LEARNING SYSTEMS

17.3

FEEDWATER -- TESTING

Goal:

The student will be able to describe tests on feedwater.

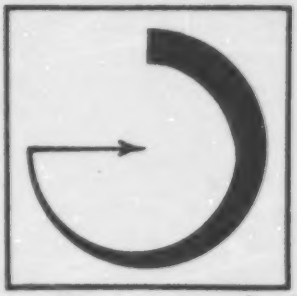
Performance Indicators:

1. Identify common test equipment, reagents and indicators.
2. Describe standard tests of water quality.

Study Guide

* Read the goal and performance indicators to find what is to be learned from package.
* Read the vocabulary list to find new words that will be used in package.
* Read the introduction and information sheets.
* Complete the job sheet.
* Complete self-assessment.
* Complete post-assessment.

Vocabulary



* Acidic
* Alkalinity
* Ammonium molybdate
* Burette
* Caustic alkalinity
* Excess phosphate
* Excess sodium sulphite
* Hydrogen ion concentration
* Indicator
* mho
* Phenolphthalein alkalinity
* pH value
* Pipette
* Sequestering agent
* Soap test
* Titration
* Total alkalinity
* Total content of dissolved solids
* Total hardness

Introduction

Feedwater testing requires exacting procedures. Testing is a laboratory function that requires clean equipment, careful sampling procedures and exact measurements.

This package is designed to introduce the apprentice to the purpose and types of tests used in maintaining the purity of boiler feedwater. Testing procedures should be obtained from test kits, manufacturers or the reference material., These specific testing instructions should be followed closely until experience has been acquired.

Information

Test Equipment Needed

- Sampling bottles
- Test tubes
- Porcelain dishes
- Pipettes
- Burettes
- Reagents
- Indicators
- Elecronic instruments

Reagents

A reagent is used to produce a chemical reaction in water. Some standard reagents used in water tests are:

- Sulphuric acid N/50
  Silver nitrate
  Potassium -- iodide-iodate solution
  Ammonium molybidate solution
  Soap solution

Indicators

Indicators are solutions that cause changes in color in a water sample depending on the Ph of the samples. Most test kits will include the following indicators.

- Phenolphthalein
- Methylorange solution
- Starch solution
- pH indicator solutions

Types of Tests

The following tests are normally carried out in testing the quality of boiler water.

- Total content of dissolved solids
- Total hardness
- Alkalinity
- Chlorides
- Excess sodium sulphite

Information

- Excess phosphate
- pH value

Total Content of Dissolved Solids

The total content of dissolved solids is usually measured by the electrical conductivity of the liquids. Solids in water offer greater electrical conductivity to a current and is measured in mho's. This term is Ohm's spelled backwards since conductivity is the opposite of resistance. Clear water is more resistant to the passage of electricity than water with solids. Instruments are available for measuring conductivity.

Total Hardness Test

The total hardness test is a measure of the salts of calcium and magnesium that are present in the water. A "soap test" uses a standard soap solution which is mixed with the water sample. The amount of soap solution needed to neutralize the hardness of the water determines the hardness of the water. The total calcium and magnesium content can also be measured by titration. A sequestering agent is mixed with the water sample in measured amounts. An organic dye will cause a change in water color from red to blue. The amount of sequestering agent used determines the hardness of the water. A formula is used for calculating the hardness of the water.

Alkalinity

Alkalinity measurements require three types of tests. The operator must determine the levels of bicarbonates, carbonates and hydroxides that are present in the water. Water treatments will differ according to the presence of these products. The tests are:

- Phenolphthalein alkalinity test for hydroxides and carbonates
- Total alkalinity for total quantity of all dissolved salts
- Caustic alkalinity for total hydroxide quantity

Chloride

This test is used to determine the rate of blow-down for a boiler. Chlorides do not precipitate which makes them a reliable indicator for calculating blow-down.

$$\frac{\text{Chlorine in feedwater}}{\text{Chlorine in boiler water}} \times 100 = \% \text{ blow down}$$

Information

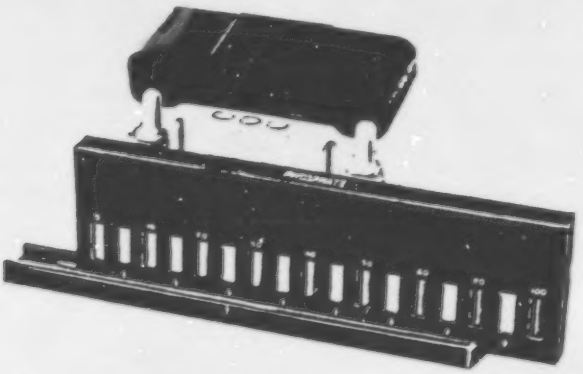
The sample is made slightly acidic by the addition of mild sulphuric acid. It is then titrated with silver nitrate until the color changes. The chlorine content can then be calculated.

Excess Sodium Sulphite

Oxygen causes corrosion inside the boiler. In order to hold down the oxygen levels, the feedwater must be tested for oxygen content. Sodium sulphite can be used to dissolve the oxygen in the water and convert it to a sulphate form. However, excess sodium sulphite can be acid forming and harmful. It is desirable to keep the sodium sulphite levels at very slightly excess levels so that oxygen will be controlled and acid conditions will be avoided. The test for excess sodium sulphite involves titrations with potassium iodide-iodate solution on samples that have been mixed with a starch solution.

Phosphate Solution

Sodium phosphates are used in boilers to precipitate calcium salts into calcium phosphates to prevent the formation of scale. It is desirable to have an excess of sodium phosphate in the boiler water at all times. Potassium nitrate crystals are mixed with the water sample and then combined with an ammonium molybdate reagent. The sample is observed for a condition of cloudiness. The time required for the cloudiness condition to occur shows whether the boilerwater has an adequate reserve of sodium phosphate. Another test can be conducted by making color comparisons on a Taylor phosphate comparator. The comparator uses standardized colors to measure the sample.

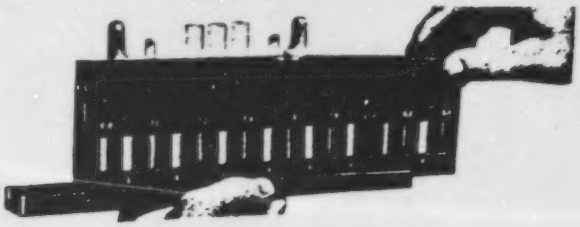


Taylor Phosphate Comparator

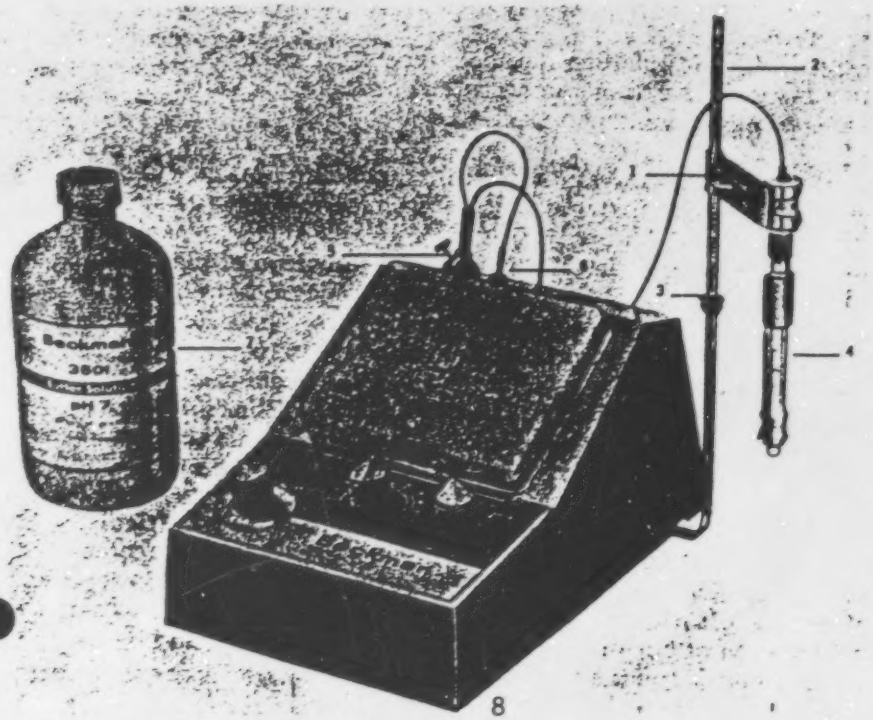
Information

pH Value

Acid conditions inside a boiler enhance corrosion. Whether the feedwater is acidic or alkaline is measured by a term pH. pH actually means hydrogen ion concentration. A pH value of 7.0 is neutral. Anything below 7.0 is acidic and everything greater than 7.0 is alkaline. pH can be measured by either colorimetric or electronic methods. Colorimetric tests involve adding indicator solutions to samples in test tubes.



Electronic tests are conducted by a pH meter such as the one shown below.



1. Electrode Clip
2. Support Rod
3. Electrode Stop
4. Combination Electrode
5. Glass Electrode Terminal
6. Reference Electrode Terminal
7. Buffer Solution

8

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Assignment

* Read pages 3 - 19 in reference.
* Complete the job sheet.
* Complete self-assessment and check answers.
* Complete post-assessment and have instructor check answers.

Job Sheet

CONDUCT pH VALUE TESTS

* Conduct colorimetric test

  - Set up test tube rack (from test kit)
  - Fill 6 test tubes with 10ml of boiler water samples
  - Fill 1 test tube with 10ml distilled water
  - Add .5 ml of indicator to a test tube
    Repeat with each type of indicator with only one indicator per test tube
  - Select the test tube which shows a color change
  - Place that test tube in a comparator and find color range

* Conduct pH meter test

  - Read instructions with pH meter to be used
  - Conduct test three times and calculate mean or average
  - Compare pH value of pH meter test with colorimetric test

Self Assessment

Match the following terms with descriptive phrases.

____	1. mho	A.	A reagent used in chloride tests.
____	2. Reagent	B.	A reagent used in testing for excess sodium sulphate.
____	3. Indicator	C.	A reagent used in testing to test for phosphates.
____	4. Silver nitrate	D.	Produces a chemical reaction in water.
____	5. Potassium-iodide-iodate	E.	Total hardness test to measure calcium and magnesium salts in water.
____	6. pH	F.	Unit of measurement for electrical conductivity.
____	7. Phenolphthalein alkalinity tests	G.	Causes changes in color of water.
____	8. Ammonium molybdate	H.	Measurement of hydrogen ion concentration.
____	9. Caustic alkalinity tests	I.	Tests for hydroxides and carbonates in water.
____	10. Soap test	J.	Tests for total quantity of hydroxides in water.

Self Assessment Answers

F 1.

D 2.

G 3.

A 4.

B 5.

H 6.

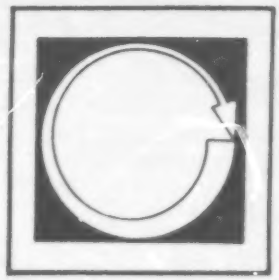
I 7.

C 8.

J 9.

E 10.

Post Assessment



1. Silver nitrate and ammonium molybdate solution are _____.

2. Phenolphthalein and methylorange solutions are _____ _____.

3. The unit of measurement for electrical conductivity (total dissolved solids) is _____.

4. The mixing of a liquid into another liquid in measured amounts until a color occurs is called _____.

5. Three types of alkalinity tests are needed to measure levels of carbonates, bicarbonates and _____.

6. The rate of blow-down for a boiler can be determined by a _____ test.

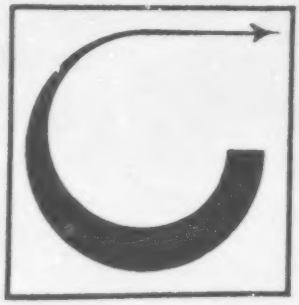
7. Sodium sulfite tests requires titrations with _____ _____ _____ _____ solutions.

8. Sodium _____ are commonly used in boilers to precipitate calcium and prevent scale formatons.

9. The pH value of water can be determined by _____ or _____ methods.

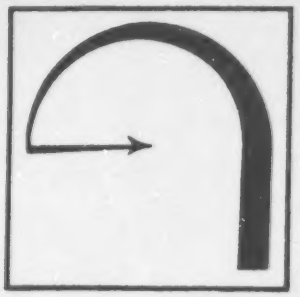
10. Hydrogen ion concentrations of liquids are commonly expressed as _____ values.

Instructor Post Assessment Answers



1. Reagents
2. Indicators
3. mho
4. Titration
5. Hydroxides
6. Chloride
7. Potassium iodide-iodate
8. Phosphate
9. Colorimetric or electronic
10. pH

Supplementary References



* Corespondence Course. Lecture 7, Section 2, Second Class. Steam Generators. Southern Alberta Institute of Technology. Calgary, Alberta, Canada.